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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application Number: 10/661,832
Filing Date: September 12, 2003
Appellant(s): HU ET AL.

MAILED
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GROUP 2800

Reza Mollaaghababa
For Appellant

EXAMINER'S ANSWER

This is in response to the appeal brief filed 12/11/2006 appealing from the Office action mailed 02/16/2006.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

No amendment after final has been filed.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

WITHDRAWN REJECTIONS

The following grounds of rejection are not presented for review on appeal because they have been withdrawn by the examiner.

The rejections of claims 15 and 17 pursuant to 35 U.S.C. 102(B) as being anticipated by Unterrainer are withdrawn as these rejections were intended to be omitted prior to the mailing of the final office action but were mistakenly not deleted.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

20040105471	Kneissl et al.	6-2004

Unterrainer et al., "Quantum Cascade Lasers with Double Metal-Semiconductor Waveguide Resonators" Appl. Phys. Lett. 80 (17), (Apr 29, 2002), pp.3060-3062

Xu et al., "Electrically Pumped Tunable Terahertz Emitter Based on Intersubband Transition", Appl. Phys. Lett 71 (4), (Jul 28 1997), pp.440-442

(9) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The factual inquiries set forth in *Graham* **v.** *John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

Claims 1-6, 8, and 15-17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Unterrainer et al. (Unterrainer et al., Quantum cascade lasers with double metal-semiconductor waveguide resonators," Appl Phys. Lett. 80. 3060 (2002)) in view of Xu et al. (Xu and Hu, "Electrically pumped tunable terahertz emitter based on intersubband transition," American Institute of Physics (1997)).

With respect to claim 1, Uterrainer teaches an active region for generating THz radiation (col.2 lines 13-15), and a waveguide formed of an upper and lower metallic layer disposed on a surface of said active layer (col.3 lines 25-27) so as to confine

selected modes of said lasing radiation within said active region. Uterrainer does not teach the active region to emit at about 1 to about 10 THz. Xu teaches an active region for generating THz radiation that emits from about 1 to about 10 THz (fig.3). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine the THz radiation emitter and waveguide of Unterrainer with the active region of Xu in order to take advantage of the fast depopulation possible through LO-phonon scattering occurring in this material at this frequency range (col.2-3 lines 10-4, fig.3).

With respect to claim 2, Unterrainer and Xu teach the cascade laser outlined in the rejection to claim 1, and further teach the waveguide to have a mode confinement factor of about 1 (Unterrainer, col.2 line 8).

With respect to claim 3, Unterrainer and Xu teach the cascade laser outlined in the rejection to claim 1, and further teach the metallic layers to have a thickness in the range of about .1 to several microns (Unterrainer, col.2 lines 36-37 bottom layer-2um, col.3 lines 18-19 top layer 300nm).

With respect to claims 4 and 6, Unterrainer and Xu teach the cascade laser outlined in the rejection to claim 1, and further teach at least one of the metallic layers to comprise a single layer formed of a selected metallic compound (Unterrainer, col.2 lines 35-37).

With respect to claim 5, Unterrainer and Xu teach the cascade laser outlined in the rejection to claim 1, and further teach one of said metallic layers to comprise a multi-layer structure, being formed by at least two different metallic compounds (Unterrainer, col.3 lines 10-19, top layer comprised of a Ti/Au pad surrounded by additional Au).

With respect to claim 8, Unterrainer and Xu teach the cascade laser outlined in the rejection to claim 1, and further teach the active region to comprise a semiconductor heterostructure providing a plurality of lasing modules connected in series (Unterrainer, col.2 lines 21-32).

With respect to claim 15, Unterrainer teaches a method of confining a mode profile of radiation in a quantum cascade laser comprising: disposing an active region of said quantum cascade laser between an upper and a lower metallic layer (col.3 lines 25-27), wherein each metallic layer has a thickness larger than a skin depth of radiation in a frequency range of about 1 THz to about 10 THz (col.2 lines 36-37 bottom layer-2um, col.3 lines 18-19 top layer 300nm). Unterrainer does not teach the active region to emit at about 1 to about 10 THz. Xu teaches an active region for generating THz radiation that emits from about 1 to about 10 THz (fig.3). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine the THz radiation emitter and waveguide of Unterrainer with the active region of Xu in order to take advantage of the fast depopulation possible through LO-phonon scattering occurring in this material at this frequency range (col.2-3 lines 10-4, fig.3).

With respect to claim 16, Unterrainer teaches forming the active region by molecular beam epitaxy (col.2 para.4)

With respect to claim 17, Unterrainer teaches the use of a wafer bonding technique to form the structure (col.2 lines 34-39).

Claims 1, 4, 6, 9-13, and 18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Xu in view of Unterrainer.

With respect to claims 1 and 10, Xu teaches an active region for generating lasing radiation in a frequency range of about 1 to 10 THz (fig.3) including the active region being surrounded by two contact layers (col.1 lines 25-30). Xu does not teach a waveguide formed of metal to confine selected modes of lasing radiation within the active region. Unterrainer teaches an active region, sandwiched by two contact layers (col.2 lines 26-27), for generating THz radiation (col.2 lines 13-15), and a waveguide formed of an upper and lower metallic layer disposed on a surface of said active region (col.3 lines 25-27) so as to confine selected modes of said lasing radiation within said active region. It would have been obvious to one of ordinary skill in the art at the time of the invention to combine the cascade laser of Xu with the metallic waveguide of Unterrainer to obtain high optical confinement factors with low waveguide loss (Unterrainer, abs.).

With respect to claims 4 and 6, Xu and Unterrainer teach the cascade laser outlined in the rejection to claim 1, and further teach at least one of the metallic layers to comprise a single layer formed of a selected metallic compound (Unterrainer, col.2 lines 35-37). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine the single layer of gold with the waveguide taught above to function as a surface-plasmon carrying layer (Unterrainer, col.2 lines 37-38), and additionally, it has been held to be within the general skill of a worker in the art to select

a known material on the basis of its suitability for the intended use as a matter of obvious design choice. *In re Leshin*, 227 F.2d 197, 125 USPQ 416 (CCPA 1960).

With respect to claim 9, Xu and Unterrainer teach the cascade laser as outlined in the rejection to claim 1, and further teach a plurality of quantum well structures collectively generating at least an upper lasing state, lower lasing state, and a relaxation state (Xu, fig.1a) such that said upper and lower lasing states are separated by an energy corresponding to an optical frequency in a range of about 1 to 10 THz (Xu, fig.3), and wherein electrons populating said lower lasing state exhibit a non-radiative relaxation via resonant emission of LO-phonons into said relaxation state (Xu, col.2-3 lines 10-4).

With respect to claims 11 and 12, Xu and Unterrainer teach the cascade laser as outlined in the rejection to claim 10, and further teach the contact layers to be heavily doped GaAs (Xu, col.1 lines 25-28).

With respect to claim 13, Xu and Unterrainer teach the cascade laser as outlined in the rejection to claim 9, and further teach the semiconductor heterostructure to be formed of Al(0.3)Ga(0.7)As/GaAs, but do not teach the active region to be composed of Al(0.15)Ga(0.85)As/GaAs. These materials are known in the art to be used with lasers. It would have been obvious to one having ordinary skill in the art at the time the invention was made to make the laser of these known materials, since it has been held to be within the general skill of a worker in the art to select a known material on the basis of its suitability for the intended use as a matter of obvious design choice. *In re Leshin*, 227 F.2d 197, 125 USPQ 416 (CCPA 1960).

With respect to claim 14, Xu and Unterrainer teach the cascade laser as outlined in the rejection to claim 9, and further teach the use of vertical transitions between the upper and lower lasing states to have less susceptibility to interface roughness and impurity scattering (Xu, col.6 lines 12-18).

With respect to claim 18, Xu and Unterrainer teach the cascade laser as outlined in the rejection to claim 1, wherein the laser would inherently function as an amplifier to incoming radiation in the 1 to 10 THz range, and additionally an input port and output port would be located at either facet of the device.

Claim 7 is rejected under 35 U.S.C. 103(a) as being unpatentable over Unterrainer in view of Xu and further in view of Kneissl et al. (US 2004/0105471).

With respect to claim 7, Unterrainer and Xu teach the cascade laser as outlined in the rejection to claim 5, but do not specify the Au to cover the Ti. Kneissl teaches a laser structure wherein the electrical contact is formed using Ti covered with Au ([0069]). It would have been obvious to one of ordinary skill in the art at the time of the invention to combine the cascade laser of Unterrainer and Xu with the Au/Ti ordering of Kneissl to improve adhesion to the semiconductor surface as well as a good bonding surface for wire bonding (Kneissl, [0069]).

(10) Response to Argument

A.

With respect to claims 1-6 and 8 having been rejected over Unterrainer in view of Xu, the Appellant has argued: "Unterrainer's teachings relate to a much shorter wavelength range, and even in that range, Unterrainer teaches away from the use of double-sided metal waveguides".

As was previously presented in the final office action, the Examiner does not agree that Unterrainer teaches away from using double-sided metal waveguides. Unterrainer is believed to have written this article to show the potential of using the double waveguides in quantum cascade lasers of a wide wavelength range (abs.) to reduce waveguide losses. Unterrainer further states, in concluding remarks (col.5 para.2-col.6 para.1), the double metal-semiconductor waveguide allows for construction of a device without restriction of a cutoff wavelength, and the increasing usefulness of the device at longer wavelengths.

1.

The Appellant has argued Unterrainer does not teach a wavelength near to the upper range of that claimed (noting the limitation is 1-10THz, rather than the argued about 300um), and that the upper range is an order of magnitude greater than the examples shown by Unterrainer. The Examiner does not dispute this difference, however, the claimed range limitation as a whole must be considered. Unterrainer specifically points out operation in the 24um wavelength regime, but does not show by example an operation in the 30-300um range as claimed by the Appellant. Unterrainer does teach longer wavelengths in the THz range can be used (col.4 para.2, suggesting at least 1THz), which overlaps with the lower end of the claimed range. The claimed

range is only 6um away from the 24um example of Unterrainer. As Unterrainer teaches in multiple sections of the article that the double metal-semiconductor waveguide is fit for use at longer wavelengths, and would have improved performance at those wavelengths (col.2 para.1, losses via mode penetration into the metal layer would decrease with increasing wavelength), it is believed that one of ordinary skill in the art would find Unterrainer's teachings do in fact motivate use at those extended wavelengths. Therefor, one of ordinary skill in the art would have a reasonable expectation of success when making the combination of Unterrainer with the slightly longer wavelength operation as taught by Xu.

The Appellant further argues that figure 2 of Unterrainer again teaches away from the use of the double metal-semiconductor waveguide device. The examiner agrees with the Appellant that the single-sided surface plasmon waveguide does have a *slightly* better threshold current density characteristic, but it is believed that Unterrainer's inclusion of this figure is to demonstrate the closeness in performance of the double-sided waveguide to that of the single-sided. Although the threshold current performance may be slightly improved for the single-sided waveguide, Unterrainer teaches the double-sided waveguide to have an optical confinement close to 1, and to be usable in a wider wavelength range than that of the single-sided guide (abstract). Thus, figure 2 is used to demonstrate the almost mirrored performance of the double-sided guide compared to that of the known single-sided waveguide, while the double-sided guide shows improvements in other desirable areas not known to the single-sided device.

The Examiner also whishes to note that the Appellant has stated on pg.5 of the brief that the arrow in figure 2 represents: "the low temperature threshold current density of an identical device with a double-sided surface plasmon waveguide". The Examiner agrees that the arrow does represent a similar double plasmon device, but not an identical device. The device represented by the arrow is that of a metal - quasi-metal (n++ doped semiconductor layer) double waveguide rather than a metal – metal double waveguide that is taught by Unterrainer.

The Appellant further argues that figure 3 of Unterrainer additionally teaches away from using the double-sided metal semiconductor waveguide. The Examiner agrees with the Appellant's description of figure 3 in that the single-sided guide does in fact demonstrate slightly improved performance at higher drive currents. Similarly to figure 2, Unterrainer teaches that figure 3 is presented to demonstrate the closeness in performance of the known single-sided guide to that of the newly taught double-sided guide. This is specifically taught at col.4 para.4 – col.5 para.1. Unterrainer further notes that the double-sided guide has a higher light output at lower currents than that of the double-sided guide (col.5 para.1). As per the lower light intensity performance of the double-sided guide at high driving currents, Unterrainer teaches that this is due to poor heat transfer to the substrate. Although this can be considered a setback, Unterrainer is quick to point out that simply improving the bonding process of the metal layers has the potential to alleviate the problem and improve the device performance (col.5 para.1).

In the end it is the Examiner's position that Unterrainer presented this article to teach the newly created double-sided metal-semiconductor waveguide as a way to

bridge the gap from the known single-sided metal waveguide terahertz emitting devices to more efficient devices able to operate at increased wavelengths. The figures of Unterrainer were presented to demonstrate the closeness in operation of these preliminary double-sided devices to those of the known single-sided devices in order to motivate their potential for use at increased wavelengths. Although the performance of the preliminary devices was slightly below that of the known single-sided devices, adjustments to the double-sided devices to alleviate the performance issues were given, along with motivation for their usefulness in longer wavelength regimes.

2.

As per Xu being used as the primary reference, the Appellant has argued that Xu is not concerned with enhancing efficiency of mode confinement and one of ordinary skill in the art would not consider using the structure of Unterrainer as Unterrainer is directed towards a different wavelength range (see brief pg.6).

The examiner concedes that Xu does not appear to be concerned with mode confinement; however, the Examiner is of the belief that Xu need not be concerned with enhancing mode confinement for one of ordinary skill in the art to desire improving upon the mode confining capabilities of the Xu system. Upon reading the article by Unterrainer in which the double-sided guide is taught to have improved confinement and low losses at extended wavelengths (noting that Unterrainer's specific example is only 6um less than that of Xu), it is believed that one of ordinary skill in the art would have a reasonable expectation of success when combing the teachings of Xu with that of Unterrainer. As Unterrainer teaches nearly the same wavelength range of that of Xu, as

well as a structure which improves mode confinement and reduces losses, the rejection of Xu in view of Unterrainer is believed to be reasonable, and obvious, to one of ordinary skill in the art.

3.

With respect to the response to the Examiner's comments, the Appellant has argued similar points to those addressed with regards to claim 1 and the Examiner rebuts similarly as above. The Examiner additionally notes Unterrainer does in fact give concrete guidance to make improvements upon the efficiency via improvement of the bonding process (col.5 para.1, as was previously noted in section 1 above).

B.

With respect to claims 15 and 17 having been rejected over Unterrainer (35 U.S.C. 102(B)), the Examiner notes the withdrawal of the 102(B) rejections, and believes the arguments moot.

With respect to claims 15 and 17 having been rejected over Unterrainer in view of Xu (35 U.S.C. 103(A)), the Appellant has argued similar points to those addressed with regards to claim 1 and the Examiner rebuts similarly as above.

C.

1.

With respect to claims 1, 4, 6, 9, and 13 having been rejected over Xu in view of Unterrainer (35 U.S.C. 103(A)), the Appellant has argued similar points to those addressed with regards to claim 1 and the Examiner rebuts similarly as above.

2.

With respect to claim 18 having been rejected over Xu in view of Unterrainer (35 U.S.C. 103(A)), the Appellant has argued similar points to those addressed with regards to claim 1 and the Examiner rebuts similarly as above. In addition, the Examiner notes the laser of Unterrainer and Xu would inherently function as an amplifier to incoming radiation in the 1 to 10 THz range, and additionally an input port and output port would be located at either facet of the device.

D.

With respect to claim 7 having been rejected over Unterrainer in view of Xu and further in view of Kneissl (35 U.S.C. 103(A)), the Appellant has argued Kneissl does make up for the alleged deficiencies in the teachings of Unterrainer and Xu. The examiner notes the Kneissl reference is used only to teach the ordering of the metal layers taught by Unterrainer, as Unterrainer is not specific as to the sequence of applying the materials. As per Kneissl not making up for the alleged deficiencies of Unterrainer and Xu, the Examiner rebuts the arguments similarly as above.

(11) Related Proceeding(s) Appendix

No decision rendered by a court or the Board is identified by the examiner in the Related Appeals and Interferences section of this examiner's answer.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

Tod T. Van Roy

Tod T. Van Roy

Conferees:

Minsun Harvey

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